MINI-ENVIRONMENT POD DEVICE, AN EXPOSURE APPARATUS AND A DEVICE MANUFACTURING METHOD USING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a mini-environment pod device, a micro-device manufacturing apparatus, e.g., an exposure apparatus, and a device manufacturing method using such a mini-environment pod device. The exposure apparatus is preferably used in a lithography process for manufacturing micro-devices.

2. Description of the Related Art

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FIG. 10 shows a structure of a conventional exposure apparatus 101 as a micro-device manufacturing apparatus. In this apparatus, a handling robot 1 draws a wafer 4 (e.g., a semiconductor substrate, a glass substrate, etc.) from a cassette 2, which stores a plurality of wafers, and carries the wafer 4 into a mechanical pre-alignment station 39. In the pre-aliment station 39, after the wafer 4 is held with a chuck 8, an alignment optical system 9 - 11 detects a wafer edge position while the wafer 4 is rotated by a θ-stage 7. Detection signals are produced and processed to calculate an orientation flat 4a direction and an off-center deviation of the wafer 4 held by the chuck 8, in order to align the wafer 4 using an X-stage 5, a Y-stage 6 and the θ-stage 7. The above-mentioned operation is a so-called "orientation flat detection". After the pre-alignment, the wafer 4 is transferred to a wafer chuck 12 of an exposure station 13 and an exposure operation is performed in a step-and-repeat manner using an XY-stage 14. Thereafter, the

handling robot 1 withdraws the exposed wafer to return it to another cassette 3. The foregoing elements are housed in a clean room environment 100.

Typically, the cassettes 2 and 3 are so-called "open cassettes" (O.C.), which are only handled while being stored in an airtight enclosure (i.e., while being isolated from outside atmosphere), such as in the clean room environment 100.

When using open cassettes, there is no problem of contaminating the wafers if cleanness in the clean room 100 is kept sufficiently high. To do so, however, is expensive, and raises the manufacturing costs. In order to avoid such increased costs, a "mini-environment pod", which provides a partially isolated space around the cassette, has been developed recently. In this arrangement, the cassette is stored in an airtight pod while being handled in the clean room. The airtight pod has an opening that is covered with a lid, which provides a particle free inside space. When the pod is installed in an exposure apparatus, the lid opens into the exposure apparatus, so that the inside space of the pod is connected to the inside atmosphere of the exposure apparatus. Therefore, even though the clean room may not be maintained at a sufficiently high level of cleanness, wafers in the pod are isolated from the clean room. Therefore, the wafers will not be contaminated by particles suspended or otherwise residing in the clean room.

There are two types of mini-environment pods, which are categorized by the lid positions and lid opening directions. One is a "bottom opening type", in which the lid (opening) is positioned in the bottom of the pod, and both the lid and the cassette are drawn out from the pod

along a top-bottom (vertical) direction. A so-called "SMIF Pod", i.e., a standard mechanical interface pod, is in practical use as an example of a bottom opening type. The other type of pod is a "front opening type", in which the lid is positioned in the front face of the pod and the lid opens in a lateral direction. A so-called "FOUP", i.e., a front opening unified pod, is in practical use as an example of a front opening type. In either type, a handling robot in the exposure apparatus picks up the wafers from the cassette in the pod and transfers them to an exposure station where the wafers are exposed within the exposure apparatus.

Meanwhile, in micro-device manufacturing apparatuses, strict measures against leakage of electromagnetic waves are also required. There are several regulations in each country to control electromagnetic interference (EMI) to be within predetermined limitations. In general, these apparatuses are covered with shielded metal chambers so that the electromagnetic waves are shielded from leakage. Although some outer parts, e.g., an acrylic window for viewing, are made of a non-shielded material, a fine wire mesh (grounded to the chamber) is provided upon these parts so that electromagnetic waves are shielded by the wire mesh.

In micro-device manufacturing apparatuses using the mini-environment pods discussed above, there are some points to improve. For example, when the mini-environment pod is attached to the chamber of an exposure apparatus, although the lid opens into the chamber, the attached pod is regarded as being a part of the chamber, which is exposed to the outside. Thus, the electromagnetic waves may leak out through the pod, because the pods are generally made of a non-shielded material, e.g., a resin.

SUMMARY OF THE INVENTION

The present invention is provided to overcome the challenges discussed above, and a general object of the invention is to provide an improved mini-environment pod device, and a micro-device manufacturing apparatus and a method utilizing the improved pod device.

It is a still more specific object of the invention to provide a mini-environment pod device and a micro-device manufacturing apparatus providing an exceedingly low or no leakage of electromagnetic waves.

According to one aspect of the present invention, a mini-environment pod device for a micro-device manufacturing apparatus comprises a cassette being able to hold a plurality of wafers, a pod providing an inner space to store the cassette, wherein the pod includes an electromagnetic shield for shielding the pod, and a lid which fits into an opening of the pod, the lid providing an isolated environment in the inner space of the pod.

According to another aspect of the present invention, a micro-device manufacturing apparatus for processing substrates comprises a shielded chamber having an opening covered with a door, a mini-environment pod, having an open end, containing a cassette for holding a plurality of wafers and including a lid covering the open end, the pod being installed over the opening of the chamber, wherein the mini-environment pod has an electromagnetic shield, and when the pod is installed on the chamber, the electromagnetic shield is in a conductive relationship with the shielded chamber, a door opener which opens the door of the chamber and the lid of the pod when the mini-environment pod is installed on the chamber, and a processing system, contained in the chamber, which processes a wafer in the chamber.

According to yet another aspect of the present invention, a semiconductor manufacturing method comprises providing a mini-environment pod device, which comprises (i) a cassette being able to hold a plurality of wafers, (ii) a pod providing an inner space to store the cassette, wherein the pod has an electromagnetic shield, and (iii) a lid which fits into an opening of the pod, the lid providing an isolated environment in the inner space; providing a micro-device manufacturing apparatus, which comprises (i) a shielded chamber having an opening covered with a door, (ii) a door opener which opens the door of the chamber and the lid of the pod when the pod is installed on the apparatus and (iii) a processing system which processes the wafer in the chamber, wherein the electromagnetic shield of the pod is in a conductive relationship with the shielded chamber when the pod is installed on the chamber; installing the mini-environment pod onto the manufacturing apparatus; opening both the door of the chamber and the lid of the pod to expose the wafer to the inside atmosphere of the chamber; picking up one of the wafers from the cassette and carrying the wafer to the processing system; and processing the wafer with the processing system.

These and other objects, features and advantages of the present invention will become more apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a structure of an exposure apparatus, including a front open type pod, for manufacturing micro-devices according to an embodiment of the present invention.

FIG. 2 is a cross-sectional view of the pod shown in FIG. 1.

FIG. 3 is a view of a flange of the pod as seen from the direction A shown in FIG. 2.

FIG. 4 is a view of one of the kinematic couplings used in this embodiment.

FIG. 5 is a view showing the arrangement of the kinematic couplings used in this embodiment.

FIG. 6 is a cross-sectional view of a modified pod.

FIG. 7 shows a structure of an exposure apparatus, including a standard mechanical interface type pod, for manufacturing semiconductors according to another embodiment of the present invention.

FIG. 8 is a flowchart showing a process for manufacturing micro-devices.

FIG. 9 is a flowchart showing the detailed steps of the wafer process in the micro-device manufacturing process shown in FIG. 8.

FIG. 10 shows a structure of a conventional exposure apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention will be described in further detail by way of example with reference to the accompanying drawings.

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FIG. 1 illustrates a structure of an exposure apparatus 110 for manufacturing micro-devices using a front open type pod (FOUP) as a mini-environment pod 20, according to an embodiment of the present invention. While the exposure apparatus 110 is one example of a micro-device manufacturing apparatus that is suitably usable, the present invention is applicable to any type of micro-device manufacturing apparatus using mini-

environment pods, e.g., resist coating apparatus, a developing apparatus, a heating apparatus, an inspection apparatus~~, etc.~~.

Referring to FIG. 1, the mini-environment pod 20 in this embodiment comprises a cassette 30 that is able to hold a plurality of wafers 31. The pod 20 provides an inner space to store the cassette 30, wherein the pod 20 has an electromagnetic shield (to be discussed in more detail below) and a lid 22, which fits into an opening of the pod 20. The lid 22 provides an isolated environment in the inner space of the pod 20.

The pod 20 is carried on and mounted by a stand 34 by, for example, an operator's hand (a so-called PGV: Physical Guided Vehicle) or by an automated robot (a so-called AGV: Auto Guided Vehicle). The pod 20 is positioned on the stand 34 by kinematic couplings 33. FIG. 4 shows one of the kinematic couplings 33, which includes a V-groove 37 on the pod side and a dowel pin 38 on the stand side fitting each other. FIG. 5 shows the arrangement of three kinematic couplings 33. Each of the kinematic couplings 33 consists of three pairs of V-grooves and dowel pins, as shown in FIG. 4. Thus, the pod 20 can be positioned on the stand 34 through the kinematic couplings 33 without deviation. Of course, the present invention is not limited to the use of three kinematic couplings. Nor is the present invention limited to the arrangement of the kinematic couplings shown in FIG. 5.

After the positioning, the pod 20 is moved horizontally using a movable mechanism (not shown) of the stand 34, toward a flange 21, which is made of a conductive material provided on a wall 19 of the exposure apparatus 110. Then, the pod 20 is pressed against the flange 21. The wall 19 is made of conductive metal panels

and is grounded so as to have an electromagnetic shielding capacity, yet the inside of the exposure apparatus 110 is filled with clean air or an inert gas.

A door 23 provided on the wall 19 fits and covers an opening defined by the flange 21 when the pod 20 is not attached, wherein the opening is provided for loading the wafers 31 from the cassette 30 in the pod 20 into the chamber 19. An unlock mechanism 24 unlocks a latch (not shown) of the lid 22. Then, both the lid 22 and the door 23, contacting each other, are opened simultaneously by an opening mechanism, which includes a swing arm 31 and an up-and-down-slider 32.

A handling robot 1 provided in the exposure apparatus 110 picks up one of the wafers 31 held by the cassette 30, and transfers it onto a wafer chuck 12 of an exposure station 15. An exposure optical system 16 is provided and includes an illuminator, a reticle stage, and a projection optical system. After an exposure operation is performed by the exposure optical system 16, the handling robot 1 returns the exposed wafer into the cassette 30 in the pod 20, or into another cassette (not shown) stored in a similar mini-environment pod (not shown) having the same structure as that of the pod 20.

FIG. 1 shows a state in which the lid 22 and door 23 have already been opened (moved down) so that the inside of the pod 20 is assimilated with the atmosphere within the exposure apparatus 110. The pod 20 is attached to the flange 21 tightly. Thus, the pod 20 itself becomes a part of the exposure apparatus, which is exposed to the outside.

In order to prevent leakage of electromagnetic waves generated by apparatuses in the exposure apparatus 110 during operation, the pod 20 includes an electromagnetic

shield as described below. FIG. 2 is a cross-sectional view of the pod 20 having the lid 22. Since the pod 20 is made of a resin (i.e., a non-electromagnetic-shield material), fine wire mesh or gauze 36, being made of a conductive metal and having a predetermined density, is provided on the inside walls of the pod 20. The resin becomes embedded in openings in the wire mesh so that the inner surfaces of the pod 20 are smooth, to prevent particle contamination on the surfaces. It is not necessary for the lid 22 to be made of a conductive material or shield material.

The pod 20 comprises a flange 41 having a contact surface on which another fine wire mesh 35 is provided, which conducts to the wire mesh 36 on the inner surfaces of the pod, as shown in FIG. 2 and FIG. 3. (FIG. 3 is a view seen from the direction shown by arrow A in FIG. 2.) When the pod 20 is attached to the exposure apparatus 110 so that the flange 41 contacts the flange 21 of the exposure apparatus 110, since the flange 21 is made of a conductive metal and is grounded to the chamber 19, all wire mesh 35, 36 of the pod 20 becomes grounded. Therefore, it is possible to shield the whole exposure apparatus 110 to prevent electromagnetic leakage. The shielding capacity increases as the density (average wires pitch) of the wire mesh becomes higher. It is preferable to set the density that the shielding capacity provides to be under 100 dB (μV) within frequencies of about 9 kHz to about 400 MHz.

Meanwhile, as the shield, it is possible to provide the fine wire mesh 36 completely within the walls of the pod 20, or on the outside of the pod 20, as shown in FIG. 6. Further, it is possible to use coatings of conductive metal on the surfaces, instead of the fine wire mesh.

Also, choosing non-electromagnetic-transparency materials instead of resins as the material used for the pod 20 could be another solution for shielding.

FIG. 7 illustrates a modified embodiment of the present invention, in which parts similar to those previously described with reference to FIG. 1 are denoted by the same reference numerals. In this embodiment, the exposure apparatus 110 has a bottom opening type mini-environment pod 26 having an opening in the bottom of the pod, i.e., a standard mechanical interface (SMIF) pod. The pod 26 has a lid 28, which supports an inside cassette 30 having a plurality of wafers 31, and is capable of opening vertically with the cassette 30. When the pod 26 is attached to the exposure apparatus 110, an unlock mechanism (not shown) provided on the door 27 unlocks a latch of the lid 28. Then, an indexer 29 as a door opener lowers the door 27, as well as the lid 28 and the cassette 30. The cassette 30 and the wafers 31 become exposed to the atmosphere within the exposure apparatus 110 and the inside of the pod 26 is assimilated with that atmosphere. The pod 26 is attached to the flange 21 tightly. Thus, the pod 26 itself becomes a part of the chamber of the exposure apparatus 110. Since the pod 26 has shields as described above, electromagnetic waves generated by the apparatuses in the chamber during operation are shielded to prevent leakage out through the pod 26.

FIG. 8 is a flow chart showing a process for manufacturing a micro-device (e.g., a semiconductor chip such as an IC or an LSI, a liquid crystal panel, a CCD (charge-coupled device), a thin film magnetic head, a micro-machine or the like). At step 1 (circuit design), the circuit design of the semiconductor device is effected. At step 2 (the manufacturing of a mask), a

mask, as the substrate described in the above embodiments, formed with the designed circuit pattern, is manufactured. On the other hand, at step 3 (the manufacturing of a wafer), a wafer is manufactured by the use of a material such as silicon. Step 4 (wafer process) is called a pre-process, in which by the use of the manufactured mask and wafer, an actual circuit is formed on the wafer by lithography techniques. The next step, step 5 (assembling), is called a post-process, which is a process for making the wafer manufactured at step 4 into a semiconductor chip, and includes steps such as an assembling step (dicing and bonding) and a packaging step (enclosing the chip). At step 6 (inspection), inspections such as an operation confirming test and a durability test of the semiconductor device manufactured at step 5 are carried out. Via such steps, the semiconductor device is completed, and it is delivered (step 7).

FIG. 9 is a flowchart showing the detailed steps of the wafer process discussed above with respect to step 4. At step 11 (oxidation), the surface of the wafer is oxidized. At step 12 (chemical vapor deposition - CVD), an insulating film is formed on the surface of the wafer. At step 13 (the forming of an electrode), an electrode is formed on the wafer by vapor deposition. At step 14 (ion implantation), ions are implanted into the wafer. At step 15 (resist processing), a photo-resist is applied to the wafer. At step 16 (exposure), the circuit pattern of the mask is printed and exposed onto the wafer by the exposure apparatus. At step 17 (development), the exposed wafer is developed. At step 18 (etching), the portions other than the developed resist image are removed. At step 19 (the peeling-off of the resist), the resist, which has become unnecessary after the etching, is also removed. By

repetitively carrying out these steps, circuit patterns are multiplexly formed on the wafer. If the manufacturing method of the present embodiment is used, it will be possible to manufacture semiconductor devices having a high degree of integration, which have heretofore been difficult to manufacture.

Except as otherwise disclosed herein, the various components shown in outline or in block form in the figures are individually well known and their internal construction and operation are not critical either to the making or using of this invention or to a description of the best mode of the invention.

While the present invention has been described with respect to what is at present considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.